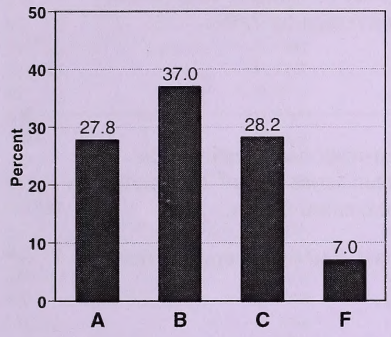
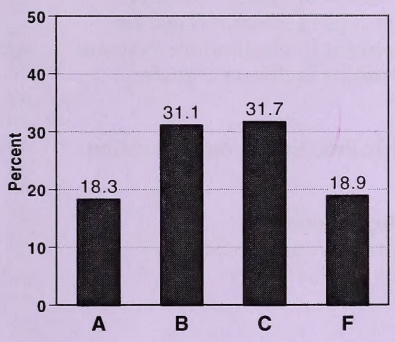
Chemistry 30

Diploma Examination Results
Examiners' Report for June 1999

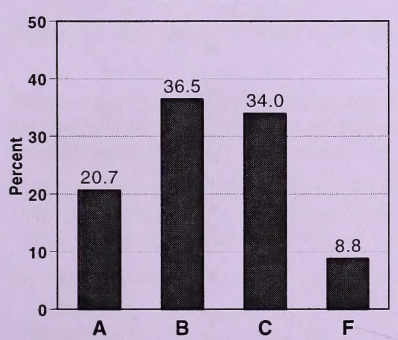
School-Awarded Mark



Diploma Examination Mark



Final Course Mark



The summary information in this report provides teachers, school administrators, and students with an overview of results from the June 1999 administration of the Chemistry 30 Diploma Examination. This information is most helpful when used in conjunction with the detailed school and jurisdiction reports that are provided electronically to schools and school jurisdiction offices. A provincial report containing a detailed analysis of the combined November, January, June, and August results is made available annually.

Description of the Examination

The Chemistry 30 Diploma Examination consists of 44 multiple-choice questions worth 55%, 12 numerical-response questions worth 15%, and two written-response questions worth 30% of the total examination mark.

Achievement of Standards

The information reported is based on the final course marks achieved by 8 389 students in Alberta who wrote the June 1999 examination and received a school-awarded mark.

- 91.2% of the 8 389 students achieved the *acceptable standard* (a final course mark of 50% or higher).
- 20.7% of the 8 389 students achieved the *standard of excellence* (a final course mark of 80% or higher).

Approximately 53.1% of the students who wrote the June 1999 examination were female. Of these, 91.4% achieved the *acceptable standard* for a final course mark, and 18.4% achieved the *standard of excellence* for a final course mark.

Approximately 46.9% of the students who wrote the June 1999 examination were male. Of these, 91.0% achieved the *acceptable standard* for a final course mark, and 23.3% achieved the *standard of excellence* for a final course mark.

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Provincial Averages

- The average school-awarded mark was 69.5%.
- The average diploma examination mark was 63.9%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 67.0%.

Approximately 7.5% of the students who wrote the examination in June 1999 and received a school-awarded mark had previously written at least one other Chemistry 30 Diploma Examination during the June 1998 to June 1999 period. This sub-population (646) achieved an examination average of 59.8%, compared with 64.1% for the population (7 743) who first wrote a Chemistry 30 examination in June 1999. The group of students who rewrote increased their exam average by 7.6%.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students achieving the *acceptable standard* will obtain a mark of 50% or higher, and students achieving the *standard of excellence* will obtain a mark of 80% or higher. The Chemistry 30 Examination requires students to apply their understanding of concepts to new situations in a clear, concise, organized fashion and to respect the conventions of the mode of communication selected.

In the following blueprint, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer. For multiple-choice and numerical-response questions, the "Difficulty" indicates the proportion (out of 1) of students answering the question correctly. For written-response questions, the "Difficulty" is the mean score (out of 1) achieved by students who wrote the examination.

Questions are also classified by general learner expectations (GLE).

Knowledge:

GLE 1 Quantitatively Predicting Outcomes
GLE 2 Qualitatively Analyzing Systems
GLE 3 Relationships in Energy Transfer
GLE 4 Relationships in Electron Transfer
GLE 5 Relationships in Equilibrium Systems
GLE 6 Relationships in Proton Transfer

Skills:

SPC Scientific Process & Communication Skills

Science, Technology, Society:

STS Connections Among Science, Technology, & Society

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPC	STS
MC1	C	0.868		✓	✓					
MC2	B	0.894		✓	✓				✓	
MC3	D	0.588		✓	✓					✓
MC4	B	0.826		✓	✓				✓	
MC5	C	0.751		✓	✓				✓	✓
MC6	C	0.629		✓	✓				✓	
MC7	C	0.760		✓	✓				✓	✓
NR1	13.2	0.660	✓		✓				✓	✓
MC8	A	0.851	✓		✓				✓	✓
MC9	A	0.418	✓		✓				✓	✓
MC10	C	0.794	✓		✓				✓	
MC11	D	0.634	✓			✓			✓	
MC12	B	0.864		✓		✓				✓
MC13	A	0.794	✓			✓			✓	
MC14	D	0.779		✓		✓			✓	
MC15	A	0.805		✓		✓			✓	
NR2	5234	0.656		✓		✓			✓	✓
MC16	C	0.583	✓			✓			✓	

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPC	STS
MC17	C	0.485	✓			✓			✓	✓
NR3	2343	0.799	✓			✓			✓	
NR4	1467	0.638		✓		✓			✓	✓
MC18	A	0.734	✓			✓			✓	✓
MC19	D	0.883		✓		✓			✓	
MC20	C	0.474	✓			✓			✓	
MC21	A	0.836		✓		✓			✓	✓
MC22	C	0.680		✓		✓			✓	
MC23	D	0.729	✓			✓			✓	
MC24	A	0.660		✓		✓			✓	
MC25	A	0.768	✓			✓			✓	
MC26	B	0.575	✓			✓				✓
NR5	4386	0.161		✓		✓			✓	✓
NR6	2.15	0.764	✓			✓			✓	✓
NR7*	3.46	0.304	✓			✓			✓	✓
MC27	B	0.568		✓	✓				✓	
MC28	B	0.897		✓			✓			
NR8	2415	0.863	✓			✓			✓	✓
MC29	D	0.620		✓			✓		✓	✓
MC30	B	0.719	✓				✓		✓	✓
NR9†	9.13	0.670	✓				✓		✓	✓
MC31	C	0.580		✓			✓		✓	
NR10	1423	0.813		✓			✓		✓	
MC32	C	0.860		✓				✓	✓	
MC33	D	0.662		✓				✓	✓	✓
MC34	A	0.496		✓				✓	✓	
MC35	D	0.688	✓					✓	✓	✓
MC36	C	0.798	✓					✓	✓	✓
MC37	D	0.737		✓				✓	✓	✓
MC38	C	0.511	✓					✓	✓	✓
MC39	D	0.147	✓		✓				✓	✓
MC40	C	0.940	✓					✓	✓	✓
MC41	A	0.616	✓					✓	✓	
MC42	B	0.703		✓				✓	✓	✓
MC43	B	0.744		✓			✓		✓	
NR11	4231	0.822	✓					✓	✓	
NR12	1.47	0.584	✓					✓	✓	
MC44	D	0.771		✓				✓	✓	✓
WR1	—		✓(6)	✓(6)	✓(8)				✓(4)	✓(12)
WR2	—			✓(12)			✓(8)		✓(4)	✓(12)

*NR7: $9.65/6 \times$ NR6

†NR9: 0.53 if A was selected from MC30; 9.13 if B was selected; 28.7 if C was selected, and 0.08 if D was selected

Subtests: Machine Scored and Written Response (Average by Subtest)

When analyzing detailed results, please bear in mind that subtest results **cannot** be directly compared. Results are in average raw scores.

Machine scored:	37.9 out of 56
Multiple choice	30.7 out of 44
Numerical response	7.1 out of 12
Written Response:	13.2 out of 24
Question 1	7.0 out of 12
Question 2	6.2 out of 12

Raw Score Averages for Machine-Scored Items and Written-Response Questions by General Learner Expectation

GLE 1	Quantitatively Predicting Outcomes	20	out of	33
GLE 2	Qualitatively Analyzing Systems	30.6	out of	47
GLE 3	Relationships in Energy Transfer	13.1	out of	21
GLE 4	Relationships in Electron Transfer	15.5	out of	23
GLE 5	Relationships in Equilibrium Systems	8.4	out of	15
GLE 6	Relationships in Proton Transfer	9.2	out of	13
SPC	Scientific Process & Communication Skills	39.0	out of	59
STS	Science, Technology, & Society Connections	31.4	out of	53

Multiple-Choice and Numerical-Response Questions

The following table gives results for four questions selected from the examination and shows the percentage of students in four groups that answered each question correctly. The comments following the table relate to some of the understandings and skills the students may have used to answer these questions.

Percentage of Students Correctly Answering Selected Machine-Scored Questions

Student Group	Question Number			
	MC 13	MC 29	NR 12	NR 5
All Students	79.4	62.0	58.4	16.1
Students achieving the *standard of excellence* (80% or higher, or A) on the whole examination	96.7	95.0	87.7	46.7
Students achieving the *acceptable standard* but not the *standard of excellence* on the whole examination	81.8	62.1	59.6	11.5
Students who have not achieved the *acceptable standard* (49% or less, or F) on the whole examination	54.8	29.5	25.8	1.7

13. In the balanced redox reaction equation
$3\ Cu_{(s)} + 2\ NO_3^-{}_{(aq)} + 8\ H^+{}_{(aq)} \rightarrow 3\ Cu^{2+}{}_{(aq)} + 2\ NO_{(g)} + 4\ H_2O_{(l)}$,
the oxidation number of nitrogen

- ***A.** decreases by 3
- **B.** increases by 3
- **C.** increases by 2
- **D.** decreases by 6

Use the following information to answer the next question.

Nitrogen monoxide, an atmospheric pollutant, can be formed in automobile engines as represented by the equation

$$N_{2(g)} + O_{2(g)} + 180.4\ kJ \rightleftharpoons 2\ NO_{(g)}$$

29. The amount of $N_{2(g)}$ at equilibrium can be increased by

- **A.** increasing the pressure by reducing the volume
- **B.** removing $NO_{(g)}$
- **C.** adding $O_{2(g)}$
- ***D.** decreasing the temperature

Use the following information to answer the next question.

A student was asked to determine the concentration of an aqueous $HCl_{(aq)}$ solution by titrating it with 1.13 mol/L $NaOH_{(aq)}$ in the presence of bromothymol blue indicator. Since burets were not available, the student used droppers for each solution and assumed that each drop was of equal volume. It took 26 drops of $NaOH_{(aq)}$ to neutralize 20 drops of the $HCl_{(aq)}$ solution and to reach the bromothymol blue end-point.

Numerical Response

12. The concentration of the $HCl_{(aq)}$ solution was _____ mol/L.
(Record your **three-digit answer** in the numerical-response section on the answer sheet.) **Answer: 1.47**

The following questions were selected for discussion because they exemplify the minimum requirements of the *acceptable standard* and of the *standard of excellence*.

Students achieving the *acceptable standard* but not the standard of excellence had no difficulty answering questions such as multiple-choice questions 5, 13, 14, 15, 18, 23, 25, 37, 42, and 43 and numerical-response questions 1, 6, 10,and 12.

For example, in **multiple-choice question 13,** most students (79.4%) were able to determine the change in the oxidation number of nitrogen in a redox reaction.

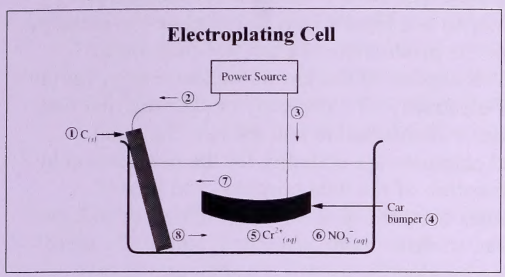
Correctly determining the magnitude of the oxidation number changes but inaccurately concluding that the change was an increase led 8.8% of all students and 18.3% of those students who did not achieve the acceptable standard to select B as their answer. Multiplying the oxidation number change by the coefficient led 5.4% of all students and 10.2% of failing students to select D as their answer.

The results from this question suggest that students who do not achieve the acceptable standard have difficulty in both assigning oxidation numbers and in determining the direction of electron transfer.

Students achieving the *standard of excellence* had no difficulty answering questions such as multiple-choice questions 3, 6, 11, 17, 22, 24, 26, and 29 and numerical-response questions 1, 2, 4, and 12.

For example, in **multiple-choice question 29**, 95.0% of students achieving the *standard of excellence* understand that a decrease in temperature for an endothermic equilibrium system will result in an increase in reactant concentrations.

Use the following diagram to answer the next question.



Numerical Response

5. Use the numbers that identify the parts of the electroplating cell in the diagram above to complete the statements below.

The cathode is identified by _____
(Record in the **first** column)
The electron movement is identified by _____
(Record in the **second** column)
The cation movement is identified by _____
(Record in the **third** column)
The anion is identified by _____
(Record in the **fourth** column)

(Record your answer in the numerical-response section on the answer sheet.)

Answer: 4386

Not recognizing that there were two moles of gas on both sides of the equation and that a change in pressure would not affect the equilibrium led 14.1% of all students and 26.0% of those students who did not achieve the acceptable standard to select A as their response. A further 23.8% of all students were unable to correctly determine the impact of the addition or removal of a species within an equilibrium system and therefore chose B or C as their response.

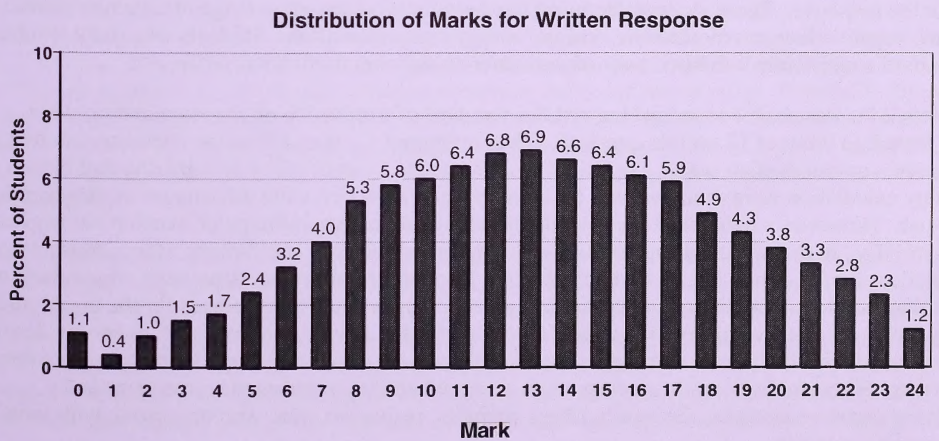
In **numerical-response question 12**, 87.7% of students achieving the *standard of excellence* were able to correctly perform a stochiometric calculation by using drops as a unit a volume.

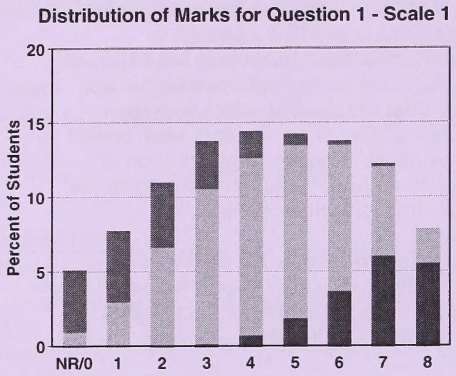
It should be noted that 12.2% of all students incorrectly multiplied the concentration of $NaOH_{(aq)}$ by the ratio of drops to obtain the concentration of $HCl_{(aq)}$ and therefore obtained 0.87 as their answer. A further 2.8% of students assumed that the concentration of $HCl_{(aq)}$ was the same as the concentration of the $NaOH_{(aq)}$ and obtained 1.13 as their answer.

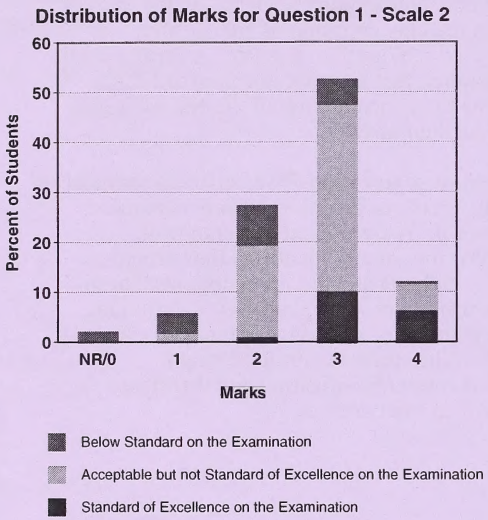
Numerical-response question 5 was difficult for most students. Only 16.1% of all students were able to correctly answer it. A significant percentage of students (34.6%) incorrectly identified the carbon electrode as the cathode and did not recognize that in order for the car bumper to be plated with chromium, it must be the cathode of an electroplating cell. A further 15.5% of the students confused anion movement with anion identification and therefore recorded 4 3 8 7 as their answer.

Written-Response Questions

Of all the students who wrote the examination, 61.4% received a mark of 12 or higher out of 24 on the written-response questions. The average mark on the written-response questions was 13.1.







Written-response question 1 was selected to measure students' ability to use Hess's Law to calculate the enthalpy of reaction for the production of a nuclear fuel and to address the STS aspects of the use of nuclear energy for the generation of electricity. To correctly answer the first part of the question, students had to add the two chemical equations and calculate the enthalpy for the net reaction by using a combination of the data provided and heat of formation values from the data booklet. In the second part of the question, students were asked to evaluate the use of nuclear energy by identifying two advantages and two disadvantages of it. Generally, students attempted all parts of the question. Students did not evaluate the use of nuclear energy per se; rather, they listed pros and cons of its use. Many students had problems with conversions involving the prefix "mega." A number of students assumed that the prefix was the abbreviation for magnesium.

Students who did not achieve the acceptable standard averaged 1.8 out of 8 on the chemistry content scale and 1.9 out of 4 on the communication scale. Of these students, 9.7% did not even attempt the question. Overall, students who did not achieve the acceptable standard averaged 3.7 out of 12 by recognizing the need for enthalpy values to answer this question and by providing at least one valid advantage or disadvantage for the use of nuclear energy. Most of these students who attempted to determine the molar mass of $UF_{6(s)}$ did so correctly. These students demonstrated an understanding of a valid method to determine the net reaction for the production of $UF_{6(s)}$. Many of these students successfully calculated the enthalpy change for the reaction of the uranium ore; however, they failed to consider the 2.00 Mg mass of $UF_{6(s)}$ in their calculations. The most common error was the incorrect application of the heat of formation values to the enthalpy of a reaction; for example $UO_{2(s)} + 4HF_{(g)} \rightarrow UF_{4(s)} + 2H_2O_{(g)}$ with a net $\Delta H = -1914.0$ kJ. This problem illustrates a limited understanding of multistep enthalpy calculations. States of matter and significant digits were either absent or not consistently applied throughout the response. These students demonstrated a poor working knowledge of common metric system conversions, negative integer calculations, and the energy sign convention. Students who did not achieve the acceptable standard consistently exhibited poor organizational and communication skills.

Students who achieved the *acceptable standard* but not the standard of excellence on the examination were expected to score from 6 to 9 out of 12 on this question. They averaged 4.3 out of 8 on the chemistry content scale and 2.7 out of 4 on the communication scale. Overall, they averaged 7.1 out of 12 by recognizing that Hess's Law and a molar enthalpy calculation were required, and by identifying at least two valid advantages or disadvantages of nuclear energy use. However, a number of these students calculated the net enthalpy of reaction but neglected the 2.00 Mg mass of $UF_{6(s)}$ in their calculations, or they did not use the reaction coefficients when determining the heat of reaction for Equation I. A number of students selected the water liquid rather than water vapour heat of formation value. Many students had difficulty elaborating on advantages and disadvantages for the use of nuclear energy. Their answers were often vague and illustrated a poor understanding of concepts such as energy density of fuels and costs associated with fuel use or its production. Incorrect assignment and use of units were common communication errors. Some students made careless math errors when they performed conversions and calculations involving negative integers. Generally, these students' responses were well organized, with units and significant digits applied correctly.

Students who achieved the *standard of excellence* were expected to score 10 or better out of 12. They averaged 6.7 out of 8 on the chemistry content scale and 3.3 out of 4 on the communication scale. Of these students, 30.4% attained full marks on the first scale, and 35.9% attained full marks on the second scale. Students who achieved the *standard of excellence* accurately connected the information provided with the referenced data to answer the question. Usually, these students provided more than one valid advantage and disadvantage and supported them well. These students demonstrated excellent attention to detail. The responses were well organized, clear, and concise.

The results for this question indicate the importance of teaching multistep enthalpy problems involving a number of common metric conversions for various types of reactions. That many students had difficulty applying Hess's Law to this nuclear problem was evidenced by their use of the unit kJ rather than kJ/mol for calculations. Generally, students had more success in the STS part of the question; however, many students were vague in their response.

On this 12-mark question, the average mark was 7.0, or 58.3%.

Written-response question 2 was selected to measure students' ability to design an experiment to explore the relationship between the K_a of a weak acid and its temperature. Students were required to design an experiment, identify the variables, and provide an indication of the calculations necessary to solve for K_a.

Overall, students were familiar with aqueous equilibrium systems and with the equilibrium expression for K_a. It was evident that some students were unclear how the data gathered in the experiment could be used to calculate K_a. The desire by a number of students to dilute the acid demonstrated a limited understanding of solvent systems or perhaps a need to create a weak acid using the relationship $HX_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + X^-_{(aq)}$. Many students did not differentiate between the variables that could be measured and the variables that were the result of calculations. Students frequently used 10^{-pH} to determine K_a.

Students who did not achieve the acceptable standard averaged 0.83 out of 4 on the chemistry content scale; therefore, they received a content mark of 1.7 out of 8. These students averaged 1.0 out of 4 on the communication scale. Of these students, 15.7% did not even attempt the question. Overall, students who did not achieve the acceptable standard averaged 2.7 out of 12 on this question. These students recognized that the question involved acid equilibrium, and they could write the equilibrium expression, K_a = [products]/[reactants]. Their experimental design included ways to change the temperature of a weak acid. These students correctly identified a number of the variables required to solve the problem; however their experimental design would not generate the values required to calculate K_a. Students were unable to explain how the K_a value related to pH. A number of these students attempted to use a "K_a meter" to measure the K_a or suggested that temperature values could be used directly in calorimetric calculations to determine K_a. Some of these students selected temperatures too high or too low to work or wrote procedures that were potentially dangerous, such as heating an acid in a closed container. Many of these students designed a titration experiment using a strong acid with the unknown weak acid. They had difficulty selecting an appropriate indicator for most experimental designs involving titrations. They were unable to distinguish between end-point and equivalence-point. Generally, these students had difficulty relating calculations and formulas identified to a workable laboratory procedure. A common misconception was that, in a closed system, an increase in the temperature of the acid would cause a significant increase in the concentration of the acid. These students' responses were poorly organized and contained many errors in conventions.

Students who achieved the *acceptable standard* but not the standard of excellence were expected to score from 6 to 9 out of 12 for their combined mark. They averaged 1.9 out of 4 on the chemistry content scale, which resulted in a content mark of 3.8 out of 8, and 1.9 out of 4 on the communication scale. Overall, they averaged 5.7 out of 12 on the question. Most of these students could write an experimental design that could be used to determine changes in K_a for a weak acid and they were familiar with the expression $K_a = [H^+_{(aq)}]\,[A^-_{(aq)}]/\,[HA_{(aq)}]$. Most of these students measured pH, correctly identified the experimental variables, and manipulated the temperature of the acid; however, their description of how the data could be used was vague and the connections from pH to

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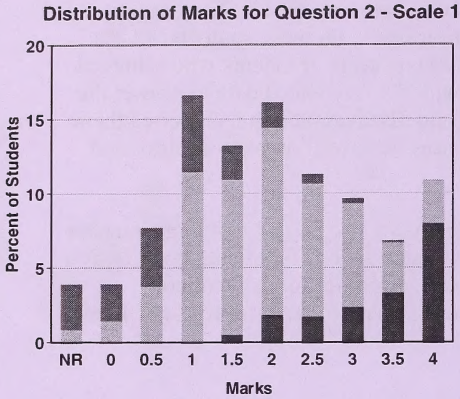

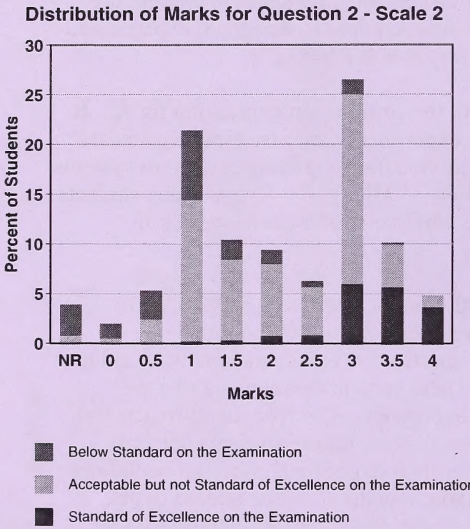

$H_3O^+_{(aq)}$ to K_a were weak. A number of the experimental designs were descriptions of the values to be somehow collected and entered into a calculator, rather than descriptions of a laboratory procedure to generate the values needed for the calculations. Students who used a titration to solve for K_a were able to select a suitable indicator and write a detailed procedure. The most common error was in the determination of K_a. Many students assumed that the [acid] = $[H_3O^+_{(aq)}]$ and often demonstrated a limited knowledge of the relationship between pH, and K_a by treating these terms as synonyms. Many students identified the K_a, rather than pH, as the responding variable and included unrelated equations such as $K_a = K_w/K_b$. These students' responses were generally well organized but had minor errors in conventions.

Students who achieved the *standard of excellence* were expected to score 10 or better out of 12. They averaged 3.3 out of 4 on the chemistry content scale, which resulted in a content mark of 6.6 out of 8. These students averaged 3.2 out of 4 on the communication scale. Of these students, 43.9% attained a perfect score on the first scale and 20.7% attained a perfect score on the second scale. Overall, they averaged 9.9 out of 12 on the question. Students achieving the *standard of excellence* did so because they could successfully design an experiment and clearly connect pH measurements to K_a changes. Many of these students recognized that titration was not necessary; however, they did not differentiate between $H_3O^+_{(aq)}$ and $H^+_{(aq)}$, and made the assumption that $[H^+_{(aq)}]^2/[\text{acid}] = K_a$. These students presented their answers in a succinct, well-written, and organized manner, with minor errors in abbreviations or minor omission of states of matter. Units and states were used correctly when needed and omitted for K_a values where they were unnecessary.

On this 12-mark question, the average mark was 6.2 or 51.6%.

For further information, contact Marlene McDonald mmcdonald@edc.gov.ab.ca, Leno Delcioppo ldelcioppo@edc.gov.ab.ca, or Corinne McCabe cmccabe@edc.gov.ab.ca at the Student Evaluation Branch at (780) 427-0010. To call toll-free from outside of Edmonton, dial 310-0000.

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